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DATE 10 March 1964

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EVALUATION OF BRAZING ALLOYS FOR THE

FABRICATION OF INCONEL 718

HONEYCOMB SANDWICH PANELS

REPORT A469 SERIAL NO. 20

MCDONNELL

This report was prepared under Contract Number AF33(657)-11215 and BPSN: 63-6899-7381-738103. Additional information pertaining to any data contained herein may be obtained from the Directorate of Materials and Processes (ASRCEM-1), Aeronautical Systems Division, Air Force Systems Command, United States Air Force, Wright-Patterson Air Force Base, Ohio, or McDonnell Aircraft Corporation, St. Louis, Missouri

INDEX
CODE (Ni-4)(I-1)(IV-a)(VI-b)

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FINAL REPORT

LABORATORY: Structures

EVALUATION OF BRAZING ALLOYS FOR THE FABRICATION OF INCONEL 718 HONEYCOMB SANDWICH PANELS

ABSTRACT

A nickel base structural alloy, Inconel 718, has been considered for use in the fabrication of honeycomb structures capable of sustained operation at elevated temperatures. Four gold-containing braze alloys were selected for compatibility testing with Inconel 718 base metal.

From the results of these tests Premabraze 128 and Premabraze 130 braze alloys appeared to be suitable for honeycomb structure brazing with Inconel 718 as base metal. No evidence was found to indicate that either of these braze alloys are susceptible to crevice corrosion. The Nicoro and Incuro 20 braze alloys were eliminated from testing because of inferior wettability and flow characteristics.

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1. INTRODUCTION

Brazed honeycomb construction can be highly efficient in the production of thin airfoil or control surface panels capable of withstanding the effects of high temperature operation. Inconel 718 has come under consideration as a base metal alloy for this type of structure, but little data concerning the compatibility of Inconel 718 and commercial braze alloys is available. Four gold-containing braze alloys were selected for study as possible Inconel 718 honeycomb brazing materials.

Wettability, lap shear, crevice corrosion, and edgewise compression tests were conducted in a braze alloy evaluation program by the McDonnell Structures Laboratory during the period 12 June through 27 November 1962.

2. DESCRIPTION OF TEST ARTICLES

2.1 Base Metal

Annealed Inconel 718 sheet stock (0.012, 0.025, and 0.043-inch thick), and honeycomb core (0.002-inch ribbon and 0.25-inch cell size) were furnished for specimen fabrication.

The chemical composition of Inconel 718, in percent, is tabulated below:

Ni	50.0-55.0	C	0.10 max.
Cr	17.0-21.0	Si	0.75 max.
Cb+Ta	4.5- 5.75	Mn	0.50 max.
Mo	2.8- 3.3	S	0.03 max.
Al	0.2- 1.0	Cu	0.75 max.
Ti	0.3- 1.3	Fe	balance

2.2 Braze Alloys

The four gold-containing braze alloys were in the form of 0.001 or 0.002 inch thick foils. Their chemical compositions and temperature characteristics are listed below:

	Premabraze 128	Premabraze 130	Nicoro	Incuro 20
% Au	72	82	35	20
% Ni	22	18	3	
% Cu			62	78
% Cr	6			
% In				2
Melt Point	1785F	1740F	1832F	1787F
Flow Point	1835F	1740F	1886F	1877F

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3. TEST PROCEDURE

3.1 Wettability Tests

Eighty Inconel 718 test blanks, one square inch in area, were sheared from 0.025 inch thick sheet material. Several of these blanks were cleaned by each of the following procedures:

3.1 Wettability Tests (Continued)

Procedure A - Vapor degreased per PS 12010;
Alkaline cleaned per PS 12030;
Rinsed with tap water, and dried by forced air.

Procedure B - Vapor degreased per PS 12010;
Pickled in 30 percent HNO_3 - 2 percent HF solution (120F) for ten minutes;
Rinsed in tap water, and dried by forced air.

Procedure C - Vapor degreased per PS 12010;
Liquid honed per PS 12045;
Rinsed in tap water, and dried by forced air.

Procedure D - Vapor degreased per PS 12010;
Alkaline cleaned per PS 12030;
Pickled in 30 percent HNO_3 - 2 percent HF solution (120F) for ten minutes;
Rinsed with tap water, and dried by forced air.

The specimens were handled with white gloves after cleaning and during layup for brazing. The braze alloys were cleaned with trichlorethylene immediately before application. The braze alloy foils were cut into 0.25-inch squares which were stacked to a depth of 0.006 inch upon each Inconel 718 wettability test blank. Two specimens were prepared with each braze alloy tested for each combination of cleaning procedure and brazing temperature.

The wettability specimens were brazed in a vacuum retort which was evacuated to a pressure lower than one micron before heating. While this vacuum was maintained, the specimens were heated to brazing temperature with a graphite cloth heating element. After brazing, the specimens were cooled to below 600F under vacuum, and then air cooled to room temperature. Test brazes were conducted at the following temperatures:

Braze Alloy	Test Temperatures (°F)
Premabraze 128	2000, 2050
Premabraze 130	1800, 1900
Nicoro	1875, 1925, 2000
Incuro 20	1860, 1910, 2000

After measurement of the flow radius, the wettability specimens were mounted for metallographic examination.

3.2 Lap Shear Tests

Inconel 718 sheet, 0.043 inch thick, was sheared into pieces 4.5 x 8 inches in area for lap shear brazes. From the wettability test results,

3.2 Lap Shear Tests (Continued)

cleaning procedure D was selected for the preparation of the Inconel 718 during this phase of the program. Also from the wettability test results, the braze alloys selected for further evaluation were Premabraze 128 and 130.

The lap shear panel parts were cleaned immediately before layup and were handled with white gloves during layup. A 0.002-inch thick braze alloy foil strip was placed between two 4.5 x 8-inch Inconel 718 pieces to form a single panel measuring approximately 9 x 8 inches in area. A 3t overlap and the minimum possible clearance were maintained during layup and brazing.

The vacuum brazing procedure followed was similar to that of the wettability test specimens, except that the time at temperature was shortened to three minutes. The Premabraze 128 lap shear panels were brazed at 2050F, and the Premabraze 130 panels at 1900F. All lap shear specimen panels were cooled in the retort, under vacuum, to below 600F before air cooling to room temperature.

After cooling, the specimens were aged by heating at 1325F for eight hours, then furnace cooling at 100F/hr to 1150F, holding at this temperature for eight hours, followed by air cooling to room temperature.

The lap shear panels were friction sawed into 0.75-inch strips with the brazed joint perpendicular to the long axis and deburred to produce specimens as shown in Figure 1 on page 15.

Lap shear specimens brazed with Premabraze 128 and 130 were tested at room temperature and at 1000F in a 60,000-pound Baldwin universal testing machine. Load was applied at a rate of 3000 lb/min until failure. The specimens tested at 1000F were heated to temperature in one minute with quartz radiant lamp banks, held at temperature for five minutes, and tested.

Three specimens joined with each braze alloy were exposed to a 20 percent salt spray solution at 95F for 100 hours per Federal Test Method Standard 151a, Method 811.1. Three additional specimens joined with each alloy were submerged in aerated water at room temperature for 100 hours. After the exposure periods, the specimens were tested under tension at room temperature to determine whether any damage had been sustained from crevice corrosion.

3.3 Honeycomb Brazing Tests

Inconel 718 face skins and cores were prepared for brazing two honeycomb specimens with Premabraze 128 as braze alloy, and two with Premabraze 130. The face skins, measuring 3.5 x 2.3 inches in length and width, were sheared from a 0.012-inch thick sheet, and the matching cores were cut from 0.63-inch material having a 0.002-inch foil thickness.

3.3 Honeycomb Brazing Tests (Continued)

The cores and face skins were cleaned according to Procedure D described in section 3.1. The braze alloys were cleaned with trichlorethylene. The parts were handled with white gloves during layup. A single sheet of 0.002-inch thick braze alloy was laid between each face skin and the core, and the specimens sealed into vacuum envelopes for brazing.

After placing the brazing envelope and specimen in the retort, the envelope and retort were both evacuated to a pressure of less than one micron. With this vacuum maintained upon the envelope, the retort was back filled to provide a differential pressure of approximately two psi on the envelope. Brazing was conducted at 2050F with Premabraze 128, and at 1900F with Premabraze 130 alloy. In each case, the specimens were held for three minutes at brazing temperature and cooled to below 300F in the envelope under vacuum.

The honeycomb specimens were heat treated similarly to the lap shear specimens, except that they were left in the brazing envelope and a continuous flow of argon gas was maintained throughout the aging cycle.

After heat treatment, the honeycomb edgewise compression specimens were machined to three inches in length and two inches in width. The two-inch ends were ground to a parallelism within 0.001 inch/inch.

With parallel loading plates clamped lightly to the specimen ends, compressive testing was conducted in a 60,000-pound Baldwin universal testing machine. Each specimen was loaded to failure at a rate of 1500 lb/min. One specimen brazed with each filler alloy was tested at room temperature and one of each at 1000F. The elevated temperature test specimens were heated with quartz radiant lamp banks and held at temperature for fifteen minutes prior to testing. The edgewise compression test setup is shown in Figure 14 on page 26.

4. TEST RESULTS

Premabraze 128 and Premabraze 130 wettability data is tabulated in Tables 1 and 2 on pages 8 and 9. Photographs of all Premabraze 128 and Premabraze 130 wettability specimens are shown in Figures 2 through 5 on pages 16 through 19, with representative specimens of Nicoro and Incuro 20 shown in Figures 6 and 7 on pages 20 and 21. Typical base metal-braze alloy interfaces of Premabraze 128 and Premabraze 130 are shown in Figures 8 and 9 on page 22.

Shear strength data for Premabraze 128 and Premabraze 130, at room temperature and 1000F, is presented in Tables 3 and 4 on pages 10 and 11

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4. TEST RESULTS (CONTINUED)

The room temperature shear strengths of Premabraze 128 and Premabraze 130, after crevice corrosion tests, are tabulated in Tables 5 and 6 on pages 12 and 13.

Edgewise compression test data obtained by testing honeycomb specimens brazed with Premabraze 128 and with Premabraze 130 braze alloys is presented in Table 7 on page 14. Photographs of all failed compression specimens are shown in Figures 10 and 11, on pages 23 and 24. Photomicrographs of typical honeycomb-to-skin brazed joints are presented in Figures 12 and 13 on page 25.

5. DISCUSSION OF TEST RESULTS

The limited quantity of gold-containing braze alloys available for the wettability tests did not permit the formation of a measurable contact angle. Therefore, a standard wettability rating could not be computed. Braze alloy selection for further testing was, therefore, based upon the measured flow radius. Extremely poor flow characteristics were exhibited by Nicoro and Incuro 20 alloys, regardless of surface preparation or brazing temperature (see Figures 6 and 7 on pages 20 and 21). Further evaluation of these two alloys was not conducted.

Both Premabraze filler alloys showed good flow characteristics, particularly upon Inconel 718 surfaces prepared by cleaning procedures B or D, as described in Section 3.1. Cleaning procedure D, requiring vapor degreasing, alkaline cleaning, HNO_3 - HF pickling, tap water rinsing, and forced air drying was selected for the preparation of Inconel 718 for brazing lap shear and honeycomb specimens.

Evaluation of the lap shear test data in Tables 3 and 4 on pages 10 and 11, revealed that joints brazed with Premabraze 128 failed at higher average shear stresses than did those brazed with Premabraze 130 (50,900 psi versus 46,200 psi) when tested at room temperature. In tests conducted at 1000F, however, Premabraze 130 joints failed at an average shear stress of 32,500 psi and Premabraze 128 joints at 31,300 psi average.

The lap shear specimens subjected to salt spray and aerated water exposure before room temperature shear tests failed generally at shear stresses higher than those developed by unexposed specimens. This probably was caused by variation in overlap or joint clearance.

Higher failing edgewise compression stresses were exhibited by the honeycomb specimens brazed with Premabraze 128 when tested at room temperature and at 1000F. A comparison of the test results is tabulated on the following page.

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5. DISCUSSION OF TEST RESULTS (CONTINUED)

Braze Alloy	Failing Edgewise Compression Stress (psi)	
	R.T.	1000F
Premabraze 128	167,600	142,300
Premabraze 130	156,500	131,300

Visual examination of the brazed honeycomb specimens indicated that Premabraze 128 tends to form larger fillets than does Premabraze 130.

6. CONCLUSION

Both Premabraze 128 and Premabraze 130 appeared suitable for brazing Inconel 718. No evidence that either of these braze alloys applied to Inconel 718 is susceptible to crevice corrosion appeared in these test results. Although the mechanical properties of structures brazed with Premabraze 128 were nearly always higher than those of similar specimens brazed with Premabraze 130, the lower brazing temperature of Premabraze 130 may be preferable because of the thermal effects on the Inconel 718 base metal.

Nicoro and Incuro 20 braze test results indicated that these alloys are unsuitable for vacuum brazing Inconel 718.

TABLE I - PREMBRAZE 128 WETTABILITY DATA

SPECIMEN NUMBER	SURFACE CONDITION (1)	BRAZE TEMP (°F)	TIME AT TEMP (min)	WETTED AREA (in^2) (2)	FLOW RADIUS (in) (3)
1	A	2000	15	0.192	0.123
2	A			0.133	0.081
3	B			0.196	0.125
4	B			0.192	0.123
5	C			0.216	0.137
6	C			0.207	0.131
7	D			0.200	0.127
8	D			0.183	0.116
11	A	2050	15	0.166	0.105
12	A			0.176	0.112
13	B			0.209	0.133
14	B			0.232	0.146
15	C			0.075	0.030
16	C			0.096	0.050
17	D			0.210	0.134
18	D			0.116	0.067 (4)

NOTES: (1) A - VAPOR DEGREASED AND ALKALINE CLEANED.
B - VAPOR DEGREASED AND HNO_3 - HF PICKLED
C - VAPOR DEGREASED AND LIQUID HONED
D - VAPOR DEGREASED, ALKALINE CLEANED AND HNO_3 - HF PICKLED

(2) AREA OF BRAZE ALLOY AFTER FLOW.

(3) RADIUS OF BRAZE ALLOY AFTER FLOW LESS RADIUS OF BRAZE ALLOY BEFORE FLOW.

(4) BRAZE ALLOY RAN OFF ONE EDGE OF SPECIMEN.

TABLE 2 - PREMABRAZE 130 WETTABILITY DATA

SPECIMEN NUMBER	SURFACE CONDITION (1)	BRAZE TEMP (°F)	TIME AT TEMP (min)	WETTED AREA (in²) (2)	FLOW RADIUS (in) (3)
21	A	1800	15	0.010	-0.070
22	A			0.019	-0.048
23	B			0.010	-0.070
24	B			0.011	-0.067
25	C			0	-0.125
26	C			0	-0.125
27	D			0.013	-0.060
28	D			0.012	-0.065
31	A	1900	15	0.107	0.060
32	A			0.146	0.091
33	B			0.144	0.089
34	B			0.134	0.081
35	C			—	— (4)
36	C			0.162	0.102
37	D			0.139	0.086
38	D			0.142	0.088

NOTES: (1) A - VAPOR DEGREASED AND ALKALINE CLEANED.

B - VAPOR DEGREASED AND HNO_3 - HF PICKLED.

C - VAPOR DEGREASED AND LIQUID HONED

D - VAPOR DEGREASED, ALKALINE CLEANED AND HNO_3 - HF PICKLED

(2) AREA OF BRAZE ALLOY AFTER FLOW

(3) RADIUS OF BRAZE ALLOY AFTER FLOW LESS RADIUS OF BRAZE ALLOY BEFORE FLOW

(4) BRAZE ALLOY RAN OFF THE EDGE OF SPECIMEN.

TABLE 3 – SHEAR STRENGTH DATA FOR PREMABRAZE 128

TEST TEMP (°F)	BASE METAL THICKNESS (in)	OVER-LAP (in)	BASE METAL AREA (in²)	BRAZE JOINT AREA (in²)	LOCATION OF FAILURE	FAILING LOAD (lb)	F_{su} (psi)	BASE METAL STRESS AT FAILURE (psi)
Rm Temp	0.042	0.140	0.0313	0.106	BJ	5325	50,200	170,100
		0.124	0.0316	0.093		5150	55,400	163,000
		0.145	0.0317	0.109		5430	49,800	171,300
		0.152	0.0319	0.115		5990	52,100	187,800
		0.136	0.0318	0.102		4340	42,600	136,500
		0.128	0.0319	0.096		5305	55,300	166,300
Average							50,900	
1000	0.042	0.135	0.0311	0.102	BJ	3060	30,000	98,400
		0.140	0.0318	0.106		3165	29,900	99,500
		0.140	0.0311	0.106		3570	33,700	114,800
		0.123	0.0314	0.093		2970	31,900	94,600
		0.123	0.0321	0.093		3160	34,000	98,400
		0.137	0.0315	0.103		2905	28,200	92,200
Average							31,300	

NOTE: BJ - Braze Joint

TABLE 4 – SHEAR STRENGTH DATA FOR PREMABRAZE 130

TEST TEMP. (°F)	BASE METAL THICKNESS (in)	OVER-LAP (in)	BASE METAL AREA (in²)	BRAZE JOINT AREA (in²)	LOCATION OF FAILURE	FAILING LOAD (lb)	F_{su} (psi)	BASE METAL STRESS AT FAILURE (psi)
Rm. Temp	0.043	0.144	0.0319	0.108	BJ	5215	48,300	163,500
		0.156	0.0324	0.117		4420	37,800	136,400
		0.115	0.0319	0.086		5245	61,000	164,400
		0.140	0.0322	0.105		4995	47,600	155,100
		0.160	0.0324	0.120		5120	42,700	158,000
		0.155	0.0324	0.116		4610	39,700	142,300
Average							46,200	
1000	0.043	0.136	0.0328	0.102	BJ	3690	36,200	112,500
		0.144	0.0342	0.108		3450	31,900	100,900
		0.134	0.0322	0.101		3300	32,700	102,500
		0.145	0.0323	0.109		3000	27,500	92,900
		0.155	0.0324	0.116		4035	34,800	124,500
		0.144	0.0317	0.108		3465	32,100	109,300
Average							32,500	

NOTE BJ - Braze Joint

TABLE 5 – SHEAR STRENGTH DATA FOR PREMABRAZE 128 CREVICE CORROSION SPECIMENS

CREVICE CORROSION TEST	BASE METAL THICKNESS (in)	OVER-LAP (in)	BASE METAL AREA (in^2)	BRAZE JOINT AREA (in^2)	LOCATION OF FAILURE	FAILING LOAD (lb)	F_{su} (psi)	BASE METAL STRESS AT FAILURE (psi)
SALT-SPRAY	0.042	0.111	0.0311	0.084	BJ	5620	66,900	180,700
↓	↓	0.117	0.0310	0.086	↓	4645	52,800	149,800
↓	↓	0.135	0.0310	0.102	↓	4655	45,6[illegible]	150,200
Average							55,100	
STANDARD CONTROLLED HUMIDITY	0.042	0.130	0.0312	0.098	BJ	5315	54,200	170,400
↓	↓	0.120	0.0312	0.091	↓	4110	45,200	131,700
↓	↓	0.128	0.0314	0.097	↓	5700	58,800	131,500
Average							52,700	

NOTE: BJ - Braze Joint;

TABLE 6 – SHEAR STRENGTH DATA FOR PREMABRAZE 130 CREVICE CORROSION SPECIMENS

CREVICE CORROSION TEST	BASE METAL THICKNESS (in)	OVER-LAP (in)	BASE METAL AREA (in²)	BRAZE JOINT AREA (in²)	LOCATION OF FAILURE	FAILING LOAD (lb)	F_{su} (psi)	BASE METAL STRESS AT FAILURE (psi)
SALT SPRAY	0.043	0.102	0.0318	0.077	BJ	4015	52,100	126,300
↓	↓	0.101	0.0320	0.076	↓	4605	60,600	143,900
↓	↓	0.120	0.0322	0.091	↓	4385	48,200	136,200
Average							53,600	
STANDARD CONTROLLED HUMIDITY	0.043	0.114	0.0324	0.086	BJ	3850	44,800	118,800
↓	↓	0.107	0.0324	0.081	↓	3865	47,700	119,300
↓	↓	0.130	0.0318	0.098	↓	4430	45,200	135,300
Average							45,900	

NOTE: BJ - Braze Joint

TABLE [illegible] – EDGEWISE COMPRESSION TEST DATA

PREMABRAZE 128 SPECIMENS

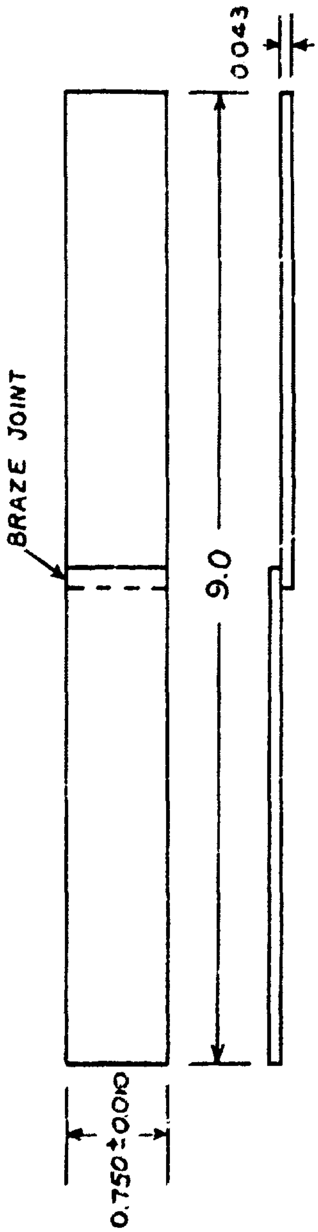
TEST TEMP (°F)	LOADING RATE (lb/min)	SKIN THICKNESS (in)	SPECIMEN WIDTH (in)	FAILING LOAD (lb)	F_{FC} (psi)	MODE OF FAILURE
Rm. Temp.	1500	0.012	2.020	8130	167,600	SKIN AND CORE CRUSHED
1000	1500	0.012	1.990	6800	142,300	

PREMABRAZE 130 SPECIMENS

TEST TEMP (°F)	LOADING RATE (lb/min)	SKIN THICKNESS (in)	SPECIMEN WIDTH (in)	FAILING LOAD (lb)	F_{FC} (psi)	MODE OF FAILURE
Rm. Temp.	1500	0.012	1.985	7450	156,500	SKIN AND CORE CRUSHED
1000	1500	0.012	1.998	6300	131,300	

FIGURE 1

LAP SHEAR SPECIMEN



NOTE: LENGTHWISE EDGES MUST BE PARALLEL WITHIN 0.003 INCH

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FIGURE 2

IN[illegible] WETTABILITY SPECIMENS WITH PREMABRAZE 12[illegible] BRAZED AT 2000F

SPECIMENS NO. 1 (LEFT) AND 2 WERE VAPOR DEGREASED AND ALKALINE CLEANED PRIOR TO BRAZING.

SPECIMENS NO. 3 (LEFT) AND 4 WERE VAPOR DEGREASED AND HNO_3-HF PICKLED PRIOR TO BRAZING.

SPECIMENS NO. 5 (LEFT) AND 6 WERE VAPOR DEGREASED AND [illegible] HONED PRIOR TO BRAZING.

SPECIMENS NO. 7 (LEFT) AND 8 WERE VAPOR DEGREASED, ALKALINE CLEANED AND HNO_3-HF PICKLED PRIOR TO BRAZING.

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FIGURE 3

INCONEL 7.. WETTABILITY SPECIMENS WITH PREPARATI[illegible] BRAZED AT [illegible]

SPECIMENS No. 11 (LEFT) and 12 WERE VAPOR DEGREASED AND ALKALINE CLEANED PRIOR TO BRAZING.

SPECIMENS 13 (LEFT) AND 14 WERE VAPOR DEGREASED AND [illegible] PRIOR TO BRAZING.

[illegible] AND 16 WERE VAPOR DEGREASED AND LIQUID [illegible]

SPECIMENS NO. 17 AND 18 WERE VAPOR DEGREASED, ALKALINE CLEANED AND [illegible] PRIOR TO BRAZING

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FIGURE 4

INCONEL [illegible] WETTABILITY SPECIMENS WITH PREMABRAZE 1[illegible] BRAZED AT 1[illegible]°F

SPECIMENS NO. 21 (LEFT) AND 22 WERE VAPOR DEGREASED AND ALKALINE CLEANED PRIOR TO BRAZING

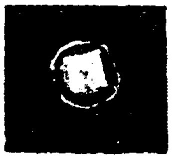
SPECIMENS 23 (LEFT) AND 24 WERE VAPOR DEGREASED AND HNO-HF PICKLED PRIOR TO BRAZING.

[illegible] (LEFT) AND [illegible] WERE VAPOR DEGREASED AND LIQUID HONED [illegible]

[illegible] (LEFT) AND 28 WERE VAPOR DEGREASED, ALKALINE CLEANED AND [illegible] [illegible] TO BRAZING.

FIGURE 6 [illegible]


[illegible]




[illegible]

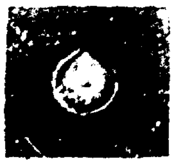




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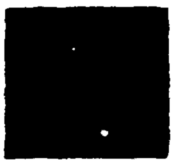
FIGURE 6

INCONEL 718 WETTABILITY SPECIMENS WITH NICORO

TYPICAL LIQUID HONED SPECIMEN AT 1875F, 1925F and 2000F

TYPICAL OF REMAINING SPECIMENS (OTHER THAN LIQUID HONED)
AT 1875F AND 1925F



TYPICAL OF REMAINING SPECIMENS (OTHER THAN LIQUID HONED)
AT 2000F

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FIGURE 7

INCONEL 718 WETTABILITY SPECIMENS WITH INCURO 20

TYPICAL LIQUID HONED SPECIMEN AT 1860F, 1910F AND 2000F

TYPICAL OF REMAINING SPECIMENS (OTHER THAN LIQUID HONED)
AT 1860F AND 1910F

TYPICAL OF REMAINING SPECIMENS (OTHER THAN LIQUID HONED)
AT 2000F

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FIGURE 8 - TYPICAL MICRO STRUCTURE OF PREMABRAZE 128
WETTABILITY SPECIMEN BRAZED AT 2050F

M-11645 MAG. 250X

FIGURE 9 - TYPICAL MICRO STRUCTURE OF PREMABRAZE 130
WETTABILITY SPECIMEN BRAZED AT 1900F

M-11988 MAG. 250X

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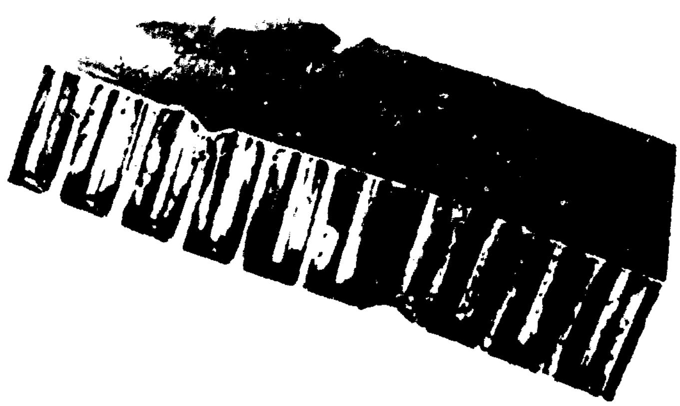
FIGURE 10 - FAILED EDGEWISE COMPRESSION SPECIMENS
PREMABRAZE 128

TESTED AT ROOM TEMPERATURE MAG. 1.5X



TESTED AT 1000F MAG. 1.5X

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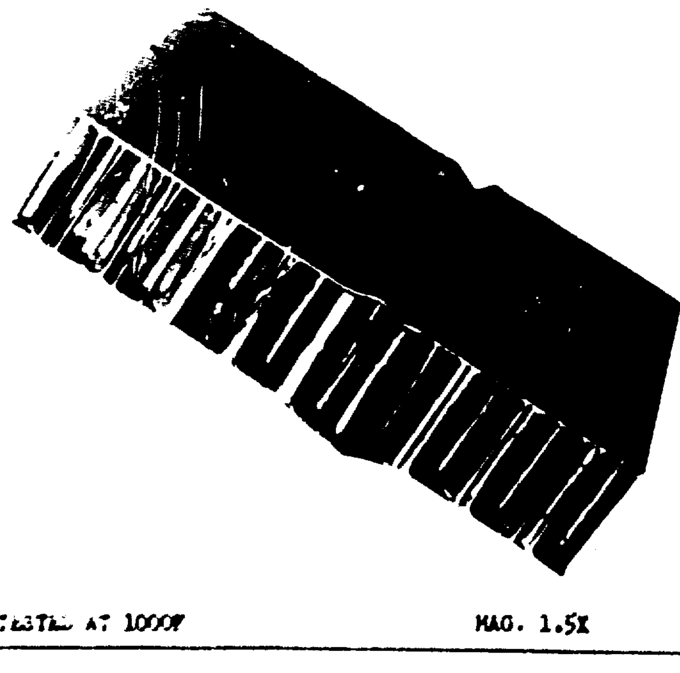
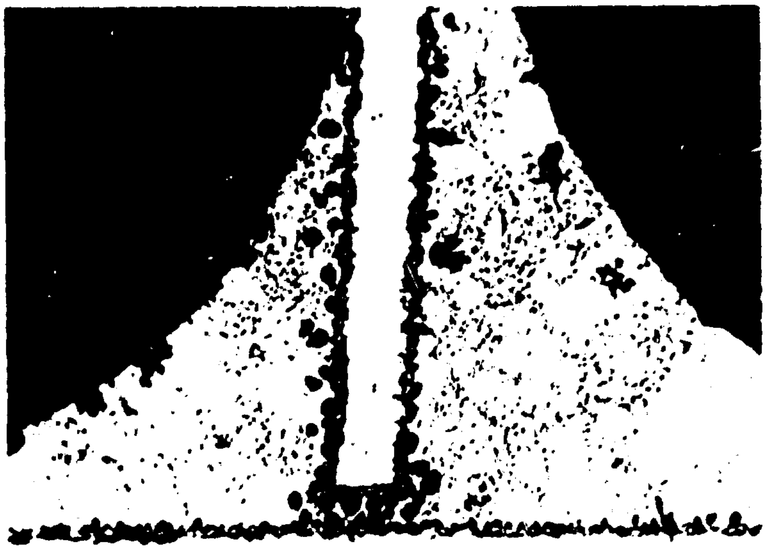
FIGURE 11 - FAILED EDGEWISE COMPRESSION SPECIMENS
FREMARRAZE 130

TESTED AT ROOM TEMPERATURE MAG. 1.5X



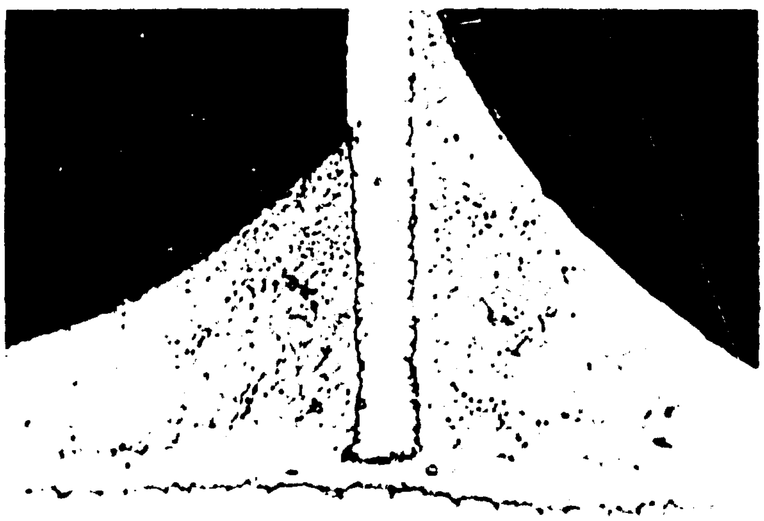
TESTED AT 1000F MAG. 1.5X

FIGURE 12 - TYPICAL PREMABRAZE 128 HONEYCOMB TO SKIN BRAZE JOINT



M-12112 MAG. 250X

FIGURE 13 - TYPICAL PREMABRAZE 130 HONEYCOMB TO SKIN BRAZE JOINT



M-12109 MAG. 250X

FINAL REPORT

FIGURE 14 - EDGEWISE COMPRESSION TEST SETUP

MAG 1000 (REV. 24 JAN. 60)
PAGE 1 OF 6

TEST REQUEST

TITLE Evaluation of Brazing Alloys for the Fabrication of Inconel 718 Honeycomb Sandwich Panels

LABORATORY OR DEPT. RESPONSIBLE FOR TEST	MODEL
Dept. 253	Misc.
TEST PARTS ON IBM ☐; ON TPL NO. ___ PRODUCTION PARTS FOR TEST NOT REQUIRED ☒	AP/EPI None

OK for IDEP WORK REQUESTED (N1-4)(I-1)(IV-a)(VI-b)

OBJECTIVE (GIVE PURPOSE OF TEST, WORK AND DATA REQUIRED, INCLUDING SERVICE HISTORY AND BACKGROUND INFORMATION)

Rev. 'D' RMIT
F6575-07E

1.0 OBJECTIVE

To obtain information needed for the selection of a brazing alloy for fabricating temperature resistant honeycomb panels using Inconel 718 honeycomb core, sheet and bar materials. Selection will be based on the results of wettability tests, shear strength of brazed joints, resistance to crevice corrosion and edgewise compression tests of sample panel specimens. Shear and compression tests will be conducted at room temperature and 1000 F.

2.0 JUSTIFICATION

In the design of temperature resistant thin airfoil sections, maximum structural efficiency can be realized by utilizing brazed honeycomb construction. The nickel base alloy, Inconel 718 is considered one of the more efficient structural materials for this application, and, at the present time very little information is available on the compatability of commercially available temperature resistant brazing alloys with Inconel 718.

3.0 TEST PLAN

Evaluation tests of brazing alloys will be conducted as follows:

3.1 Wettability Tests - Test specimens of Inconel 718 sheet containing measured quantities of candidate brazing alloys will be subjected to controlled brazing treatments at two brazing temperatures. Since wettability depends to a great extent on metal surface cleaning procedures, four different cleaning methods will be included as a part of this investigation. Rev C. als actual C.N.F 7-31-63

REFERENCES OR ENCLOSURES

Expendable Mat'ls
* IDEP Req'd

Bronze Alloys $320
Misc 80
Total $400

REV. B - CHANGE NO REVISION PER MEMO MP 62-262 RMIT

3.2 Shear Tests - Lap shear specimens will be prepared using only those brazing alloys which have adequate wettability as determined in 3.1, above. The brazing temperature and cleaning treatment will also be limited to the most satisfactory temperature and treatment as determined in 3.1.

3.3 Crevice Corrosion Tests - Lap shear test specimens, prepared as in 3.2, will also be used in this investigation to determine the effect of salt spray and aerated water on resistance to crevice corrosion of brazed joints.

3.4 Edgewise Compression Tests - The information obtained in 3.1, 3.2 and 3.3 will be used as a basis for selecting the most suitable brazing alloy or alloys, brazing temperatures and cleaning treatment for fabricating edgewise compression test specimens for final evaluation.

4.0 TEST MATERIALS

4.1 Inconel 718 sheet, 0.012 inch thick.

4.2 Inconel 718 sheet, 0.040 inch thick.

4.3 Inconel 718 honeycomb core, 0.75 to 1.00 ± .003 thick x 3.125" x 2.125" 3/16 square cell 0.002 inch ribbon, perforated.

4.4 Brazing alloys.

4.4.1 Premabraze 128, 0.0015 in. foil.

4.4.2 Premabraze 130, 0.0015 in. foil.

4.4.3 Nicoro (Au, Cu, Ni), 0.0015 in. foil.

4.4.4 Incuro 20 (Au, Cu, In), 0.0015 in. foil.

5.0 PREPARATION OF TEST SPECIMENS

5.1 Wettability specimens

5.1.1 Shear 0.040 in. Inconel 718 sheet in the annealed condition into pieces 1.0 x 1.125 in. Prepare 16 pieces for evaluation of each brazing alloy.

5.1.2 Clean 4 specimens as follows:

5.1.2.1 Vapor degrease per MAC P.S. 12010.

5.1.2.2 Alkaline clean per MAC P.S. 12030 Type II for 5-15 minutes and rinse.

5.1.3 Clean 4 specimens as follows:

5.1.3.1 Vapor degrease per [illegible] P.S. 12010.

5.1.3.2 Immerse in nitric-hydrofluoric acid pickle solution at 70-140 F. for 15-90 minutes. Pickle only long enough to remove oxides. Rinse in tap water.

5.1.4 Clean 4 specimens as follows:

5.1.4.1 Vapor degrease per [illegible] P.S. 1201[illegible].

5.1.4.2 Liquid hone per [illegible] P.S. 12045.

5.1.5 Clean 4 specimens per [illegible] P.S. 12050 for Inconel X material.

5.1.6 After cleaning handle all parts with clean white gloves until brazing is complete.

5.1.7 Place brazing alloy in the center of each specimen using the procedure described in T.R. 513-296.

5.2 Shear specimens

5.2.1 Shear 6 pieces 4.56 x [illegible] in. of 0.040 in. annealed Inconel 71[illegible] sheet material for evaluation of each selected brazing alloy.

5.2.2 Clean all pieces using the optimum method as determined from wettability tests. After cleaning, handle with clean white gloves until brazing is complete.

5.2.3 Tack weld pieces to make 3 panels [illegible] x [illegible] in. with lapped joints. Use 3t overlap, and 0.0015 in. shim stock in the joint to maintain clearance for brazing alloy.

5.2.4 Place brazing alloy in position in joints of 3 panels for each brazing alloy being evaluated and braze.

5.3 [illegible] Compression Test Specimens

5.3.1 Shear [illegible] pieces 3.1[illegible] x [illegible].125 in. of 0.012 in. annealed Inconel 718 sheet material for each selected brazing alloy.

5.3.2 [illegible] pieces of [illegible] honeycomb core .75 ± .005 in. thick by [illegible].12[illegible] x [illegible] in. for each brazing alloy. [illegible] direction shall be [illegible] the [illegible].125 in. dimension.

5.3.3 Clean all pieces using the optimum method as determined from wettability tests. After cleaning handle with clean [illegible] gloves until brazing is complete.

5.3.4 Assemble compression specimen components with brazing alloy material in a suitable brazing fixture in preparation for brazing.

6.0 BRAZING TREATMENT

6.1 Braze all test specimens in vacuum. (Minimum pressure available).

6.2 Brazing temperatures for wettability tests shall be as shown below. Time at temperature shall be 15 minutes. Cool to room temperature.

Premabraze 128, (1900 and 1950 F.)

Premabraze 130, (1800 and 1850 F.)

Nicoro (Au, Cu, Ni)(1875 and 1925 F.)

Incuro 20 (Au, Cu, In) (1860 and 1910 F.)

7.0 HEAT TREATMENT

After brazing, retain all specimens in the brazing envelope and heat to 1325°F., hold for 8 hours, furnace cool at 100 F./hr. to 1150 F., hold at 1150 F. for 8 hours and air cool. Circulate pure dry argon through the envelope during heat treatment.

8.0 SPECIMEN PREPARATION

8.1 Shear Specimens - Cut shear panels in strips and machine test specimens to the geometry shown in Figures 1 and 2 for room temperature and elevated temperature specimens respectively. Prepare a total of 12 room temperature specimens and 6 elevated temperature specimens for each alloy.

8.2 Edge Compression Specimens - Machine edges of all specimens in accordance with Paragraph 7.2.1 of AIC Report No. ARTC-17. Finished dimensions shall be 2.00 x 3.00 in. x brazed thickness.

9.0 TESTS

9.1 Wettability Tests - Examine all specimens using the method described in T.R. 513-296.

9.2 Shear Tests - Test six specimens in tension at room temperature (0.005 in./min.) and six at 1000 F. Record load at failure, joint shear stress at failure and location of failure.

9.3 Crevice Corrosion Tests - Expose three lap shear specimens to a 20% sodium chloride solution per Fed. Test Method Std. No. 151a, Method 811.1 for 100 hours and load in tension to failure at room

(Continued) ·

temperature. In addition, expose three lap shear specimens to 100 hours in a standard controlled humidity environment and test at room temperature. Record load at failure, joint shear stress at failure and location of failure.

9.4 Edge Compression Tests - Conduct tests at room temperature and at 1000 F. in accordance with the procedure described in Paragraph 7.2.2 of ATC Report No. AKTC-17. Record load at failure, facing stress at failure and mode of failure.

10.0 DATA REQUIRED

10.1 The following information is required for all tests:

10.1.1 Detailed cleaning procedures.

10.1.2 Detailed brazing procedures. (temperature, time at temperature, etc.)

10.1.3 Detailed heat treating procedures.

10.2 Wettability Tests

10.2.1 Wetting index values.

10.2.2 Photomacrographs and photomicrographs of all specimens.

10.3 Shear Tests

10.3.1 Joint shear stress at failure.

10.3.2 Base metal stress at failure.

10.3.3 Location of failure.

10.3.4 Test temperature

10.3.5 Loading rate.

10.4 Crevice Corrosion Tests

10.4.1 Complete description of environmental conditions.

10.4.2 Joint shear stress at failure.

10.4.3 Base metal stress at failure.

10.4.4 Location of failure.

10.4.5 Loading rate.

10.4.6 Photomicrographs of any indications or evidence of crevice corrosion.

10.5 **Edge Compression Tests**

10.5.1 Load at failure.

10.5.2 Facing stress at failure.

10.5.3 Mode of failure.

10.5.4 Test temperature.

10.5.5 Loading rate.

10.5.6 Diagrammatic and/or photographic description of test set-up.

10.5.7 Photomicrographs of typical honeycomb to skin brazed joints and any unusual conditions observed.

10.5.8 Photographs of failed specimens.